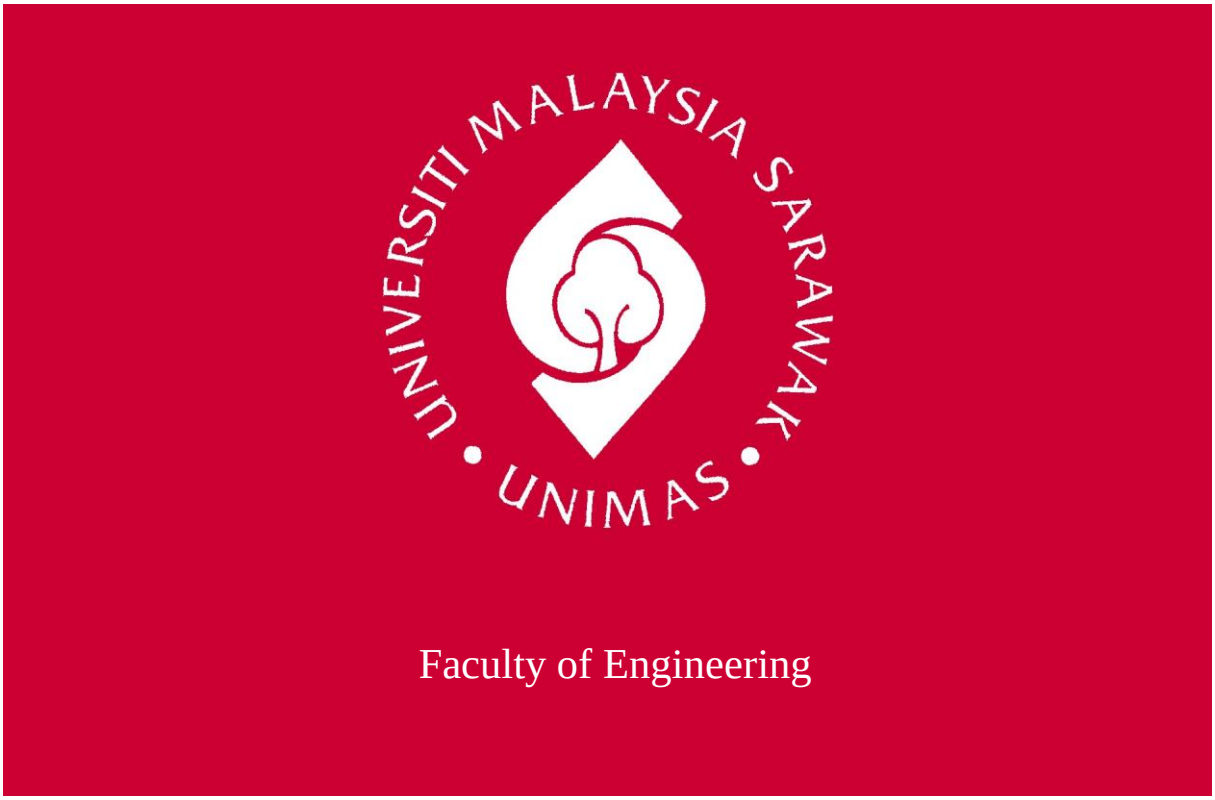

PROSPECT OF BIODIESEL PRODUCTION FROM CHICKEN BY PRODUCTS

BIBI NAJLAA BT BUNIAMIN KHAN

Bachelor of Engineering with Honours

(Mechanical and Manufacturing Engineering)

2009

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This project is submitted to Faculty of Engineering University Malaysia Sarawak (UNIMAS) as to fulfill the requirements of the degree of Bachelor of Engineering with Honours (Mechanical and Manufacturing Engineering) 2009

Faculty of Engineering

UNIVERSITY OF MALAYSIA SARAWAK

UNIVERSITI MALAYSIA SARAWAK

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ABBREVIATIONS

Notations	Description
USA	The United States of America
NO_x	Nitrogen emissions
EERE	Energy Efficiency and Renewable Energy
EPA	Environmental Protection Agency
GHGs	Greenhouse gases
IEA	International Environmental Agency
DNA	Deoxyribonucleic Acid
HFRG	High Frequency Reciprocating Rig
EN 590	European diesel fuel standard
DOE	Department of Energy
CO_2	Carbon dioxide
UK	United Kingdom
EU	European Union
ASA	American Soybean Association
PTM	Pusat Tenaga Malaysia
EC	Energy Commission
MECM	Ministry of Energy, Communications and Multimedia
POIC	Palm Oil Industrial Cluster
FFAs	Fee fatty acids
ASTM	American Society of Testing and

	Materials
CEN	European Committee for Standardization
B0	Pure diesel
B5	5% biodiesel and 95% diesel
B10	10% biodiesel and 90% diesel
B15	15% biodiesel and 85% diesel
B20	20% biodiesel and 80% diesel
B50	50% biodiesel and 50% diesel
B100	Pure biodiesel
SFC	Specific fuel consumption rate
BHP	Brake horsepower
IHP	Indicated horsepower
KOH	Potassium hydroxide
H_2SO_4	Sulphuric acid
mL	Milliliters
kW	Kilo Watt
cos	Cosine

ABSTRACT

In recent years, the world has been triggered with the development of renewable energy sources that has a bright potential to replace the primary energy sources, which are the fossil fuels. One of the most famous renewable energy sources nowadays is the biodiesel. Biodiesel undergoes a simple transesterification process that separates the glycerine by-product from the biodiesel yielded. It is produced from renewable sources, such as, animal fats, vegetable oil, algae, recycled restaurant grease and used cooking oil. In the present study, the biodiesel was produced from chicken fats. Its performance was evaluated by using diesel engine model TNM – TDE – 700 and compared with conventional diesel. The biodiesel was divided into five blends; B5, B10, B15, B20 and B50. The performance was indicated in terms of speed, specific fuel consumption rate (SFC), brake horse power (BHP) and mechanical efficiency. Based on the calculation conducted and graphs constructed, B20 had the best performance compared to other blends. By using B20 as fuel, the highest speed achieved was (1515.67 rpm), highest brake horse power (35.902 kW), highest mechanical efficiency (62.11%) and the lowest specific fuel consumption (9.665 mL/kW). Hence, biodiesel of blend B20 can be considered as another optional renewable energy sources that the world can rely on instead of fossil fuels since the B20 performance is better than pure diesel. Biodiesel also contributes less to air pollution and can reduce the emissions of the greenhouse gases.

ABSTRAK

Sejak kebelakangan ini, dunia telah didedahkan dengan perkembangan sumber tenaga yang dapat dibaharui yang mempunyai peluang yang cerah untuk menggantikan sumber tenaga utama, iaitu bahan api fosil. Biodiesel merupakan salah satu daripada sumber tenaga yang dapat dibaharui sekarang. Biodiesel dihasilkan melalui proses transesterifikasi yang mengasingkan gliserin daripada biodiesel yang terhasil. Ia dihasilkan daripada sumber yang dapat dibaharui seperti, lemak haiwan, minyak sayuran, alga dan minyak masak terpakai. Untuk ujikaji ini, biodiesel telah dihasilkan daripada lemak ayam. Prestasi biodiesel dinilai menggunakan diesel enjin model TNM – TDE – 700 dan dibandingkan dengan diesel asli. Biodiesel yang terhasil dibahagikan kepada lima campuran, iaitu B5, B10, B15, B20 and B50. Prestasi dinilai dari segi kelajuan, spesifikasi kadar bahan api digunakan, kuasa brek kuda dan kecekapan mekanikal. Berdasarkan pengiraan dan graf yang terhasil, B20 menunjukkan prestasi yang paling cemerlang berbanding campuran yang lain. Dengan menggunakan B20 sebagai bahan bakar, kelajuan tertinggi yang dicapai ialah 1515.67 rpm, kuasa brek kuda tertinggi ialah 35.902 kW, kecekapan mekanikal tertinggi ialah 62.11% dan spesifikasi kadar bahan api digunakan yang terendah ialah 9.665 mL/kW. Oleh itu, biodiesel campuran B20 boleh dipertimbangkan sebagai alternatif sumber yang dapat dibaharui yang dapat diharapkan oleh dunia selain bergantung harap dengan bahan api fosil. Biodiesel kurang menyumbang kepada pencemaran udara serta mengurangkan penyebaran gas rumah hijau.

CHAPTER 1

INTRODUCTION

1.1 Background

Biodiesel is a form of mono-alkyl esters of long chain fatty acids which is produced from renewable sources, such as, animal fats, vegetable oil (soy, canola and palm), and algae, recycled restaurant grease and used cooking oil. It is a clean burning alternative diesel that undergoes a simple transesterification process to separate the glycerin from the animal fats or vegetable oil. This process yields methyl esters and glycerin.

According to United States (US) National Biodiesel Board, biodiesel is a renewable source of energy which is environmental friendly and "more biodegradable than sugar and less toxic than table salt". Besides that, it contributes less to air pollutions. There are no sulphur dioxide emissions since biodiesel does not have any sulphur. Nitrogen emissions (NO_x) emissions may occur during the production of biodiesel but that amount can be decreased to the amounts of which are still less than the fossil fuels level of nitrogen emissions.

This statement is supported by Dr Debbis Leung Yiu Cheong, an associate professor at the University Of Hong Kong Department Of Mechanical Engineering (*http://journeytoforever.org/*). He said that animal fat which contains no sulphur can be converted into more environmentally friendly biodiesel because it does not solidify. The Energy Efficiency and Renewable Energy (EERE) Biomass Program noted that US Environmental Protection Agency (EPA) report showing that biodiesel and e-diesel (ethanol blended with petroleum) fuels substantially reduced emissions of key air pollutants from heavy-duty highway engines, except for nitrogen oxides emission (Kruger, 2006). Table 1.1 below shows the average impacts of biodiesel for heavy-duty highway engines (Kruger, 2006).

Table 1.1 Average Impacts of Biodiesel for Heavy-duty Highway Engines

	Reduction (in %) for biodiesel blends	
	100 %	20%
Carbon monoxide	-47	-12
Hydrocarbons	-67	-20
Particulates	-48	-12
Nitrogen oxides	+10	+2

In additional, biodiesel is able to reduce the emissions of the greenhouse gases (GHGs). A study conducted by the International Environmental Agency (IEA) found that estimates for net GHG emissions reduction from biodiesel ranged between 40

and 60% if compared to conventional diesel fuel (Dewulf *et al*., 2006). The combustion of biodiesel is cleaner up to 75% compared to the combustion of petroleum diesel fuel. According to US Environmental Protection Agency, biodiesel decreases the unburned hydrocarbons by 93%, carbon monoxide by 50%, particulate matter in exhaust fumes by 30%, nitrited PAH compounds by 90% and cancer-causing PAH by 80% *(http://journeytoforever.org/)*. This statement is proved by the study of Chemical and Bioassay Analyses of Diesel and Biodiesel Particulate Matter, November 1996. The study found that the use of pure rapeseed oil has produced the lowest emissions and least genotoxic (DNA-damaging) compared to 20%, 50% of rapeseed oil blend and pure diesel fuel *(http://journeytoforever.org/).*

In the terms of energy efficiency, biodiesel performance is the quite the same with petroleum diesel. It can be used in most diesel engines, especially new ones and no modifications are required. Biodiesel has a larger number of cetane number compared to petroleum diesel since it has more oxygen content. Higher number of cetane number leads to a better performance in diesel engines, whereby the engines start more easily, run better and burn cleaner. Among the various feedstock materials for biodiesel production, tallow-derived biodiesel has a cetane number that can reach up to 74 (Hilber *et al*., 2005). A comparative life-cycle study done by US Department of Energy's National Renewable Energy Laboratory has proved that biodiesel needs only 0.31 units of fossil energy to make single unit of fuel. In the other hand, it takes about 1.2 units of fossil energy to yield single unit of petroleum diesel *(http://www.ott.doe.gov/biofuels/docs/lifecycle).*

The lubricity behavior of biodiesel is also ahead of petroleum diesel. Better lubricant can help to extend engine life by producing cleaner emissions. Since biodiesel can be added to petroleum diesel in any proportion without the mixing additive, it can be mixed to petroleum diesel to increase its lubricity. For example, 1% of biodiesel mixed with petroleum diesel will increase the lubricity up to 65% (Hilber *et al*., 2005). This is proved by the best performance of 0.5% biodiesel produced by tallow when added to low-sulphur diesel (Hilber *et al*., 2005). According to European diesel fuel standard EN 590, the limit for lubricity for High Frequency Reciprocating Rig (HFRR) 60C test is below 460 micrometer. Biodiesel derived from tallow has the limit of 443 micrometer and it prescribed the European diesel fuel standard EN 590 (Hilber *et al*., 2005). Besides that, the net energy ratio of biodiesel can reach more than 1. An analysis conducted by DOE in 1998, biodiesel made from soybean oil has 3.2 net energy ratios (Dewulf *et al*., 2006).

With the emissions of carbon dioxide grows rapidly due to fossil fuel combustion, global warming has increased and bring harms towards the greenhouses. The combustion of biodiesel is carbon-neutral and CO_2 released from this combustion is part of the current natural cycle. It does not act as greenhouses gases and increase the global warming. Upon the wide benefits gained from the production of biodiesel, the development and wider exposure towards its production should be highlighted in order to save our mother earth and humanity.

1.2 Overview of biodiesel in worldwide

In the early days, the primary fuels to power the diesel engines were the vegetable fuels. Rudolph diesel, the inventor of the diesel engines, believed that vegetable based fuels would play an important role in human lives someday and be the future of fuel (Butler, 2007). However when the fossil fuels become famous during 1920s, the world have shifted the usage of fossil fuels instead of vegetable fuels. Until today the world is mainly relying on the conventional fuel, such as, coal, petroleum and natural gas. These conventional fuels are used widely in many sectors and one of them is to generate electricity for the purpose of powering human technologies. Table 1.2 below shows that in 1989, big countries, such as United Kingdom (UK) and United State of America (USA) and also European Union (EU), are still relying on the conventional thermal (coal, petroleum and natural gas) as the method of electricity production (Boyle, 2004).

Table 1.2 Final Annual Energy Consumption of UK, USA and EU for 1989

Method of electricity production	**UK (%)**	**USA (%)**	**EU (%)**
Hydro	2.10	9.06	8.22
Nuclear	22.94	18.99	35.66
Wind/solar/wave/tide/ geothermal/biofuel	Negligible	0.34	0.24
Conventional thermal	74.96	71.61	55.88
TOTAL	100.00	100.00	100.00

As we can see, during 1989, the biofuel was the least used method of electricity production for UK, USA and EU. It shows that during that time, the exploration of biofuel is not yet to be done rapidly compared to during this millennium era. In terms of the latest biofuel industry, it can be divided into two categories and they are the biodiesel and ethanol fuel. Biodiesel and ethanol fuel are the most type of biodiesel that have been produced. The production of both new sources is affected by many factors and the main three factors are in terms of geography, natural sources and technology.

In US, the investors and researchers are more keen towards ethanol fuel. Even though the price of biodiesel is more expensive than any ordinary diesel in US, there are a growing number of biodiesel suppliers in US and the sales are rising fast. The most common biodiesel blend used in US is B20 and recently lower blends of biodiesel, such as B5 are becoming popular (Dewulf *et al*., 2006). With recent incentives given by US government, biodiesel production in US has increased from about 1.89 million liters in 1999 to over 250 million liters in 2005 (Dewulf *et al*., 2006).

Biodiesel is more widely used in Europe compared to ethanol fuel, making it as the biggest biodiesel user compared to other region. Since the tax incentives offered by the government, the EU countries produced 2.2 billion liters of biodiesel in 2004 (Dewulf *et al*., 2006). German, the biggest biodiesel producer in the world, produced 1.15 billion liters (Dewulf *et al*., 2006), which is about half of the EU's biodiesel production. The second largest biodiesel producer is France with about 387 million liters (Dewulf *et al*., 2006).

According to European Commission regulations, at least 5.75% of the annual fuel consumption in Europe will have to be substituted by renewable fuels like biodiesel, by 2010 (Boyle, 2004). Since biofuel industry has become one of the important industries in Europe, some of the European countries have provided variety of incentives and support towards anyone who involves in this biofuel industry, both individual and multinational companies. For example, the German government has imposed a low fuel tax rate towards biodiesel. There are thousands of filling stations in German that supply biodiesels and the price is cheaper compared to other ordinary diesel fuel. While in France, all fossil fuels sold contain between 2% and 5% of biodiesel (Boyle, 2004).

Mega companies that produce cars in Europe, such as Audi and Volkswagen, have actively developed dual function engine diesel. They also received support from vendor such Bosch and Denso (Iznan, 2006). This alliance helps to boost the integration of biodiesel in the engine car diesel commercial sector. Besides that, most of European vehicle manufacturers are providing vehicle warranties that cover the usage of pure biodiesel and there are other European countries which have set biodiesel as their alternative fuel to be used as the national fuel in the future time. A proper research, technology development in biodiesel and the sector of engines based on biodiesel have played their role as the catalysts towards the rapid development of biofuel industry in Europe.

In US, the government has also realized the importance and future growth of biodiesel. In 2004, the Congress has passed a biodiesel tax credit of $1/gal for agri-biodiesel and 50cents/gal for other types. The tax is expected to be expired in 2008

(Oilgram News, 2007). In May 2004, Vito Fossella, a New York City congressman has sponsored the legislation to double the tax credit in producing biodiesel from used grease collected from the restaurant. A republican representative, Tim Walberg has also introduced legislation on 3rd of May, which requires that all diesel fuel sold in US must contain, on the average of 2% of biodiesel within in five years time. The biodiesel industry in US has produced 25 million gal during 2004 (Oilgram News, 2007).

Taiwan has also involved in the biodiesel industry. The Taiwan chapter of the American Soybean Association (ASA), supported by the US National Biodiesel Board, has finished completing the dossiers of soy-based biodiesel. They are applying to register the soy-based biodiesel as the clean fuel. In September, the road tests involving a local bus fleet has been conducted. The bus will run on its regular fleet for two and a half months to generate data. If this project is approved, the government of Taiwan will collaborate with ASA to enhance the development of soy-based biodiesel production and giving incentive programs for those who are involved in this potential project (*http://journeytoforever.org/*).

1.2.1 Prospect of development biodiesel production in Malaysia

Until nowadays, the primary source of energy in Malaysia is the fossil fuels (coal, petroleum and natural gas). But it is expected that our country will be without fossil fuels in 19 years from now. So, many crucial strides have been implemented by the Malaysian governments in order to solve this problem and hence to conserve this